

Surface emissions from future ship traffic in the Northern Passages

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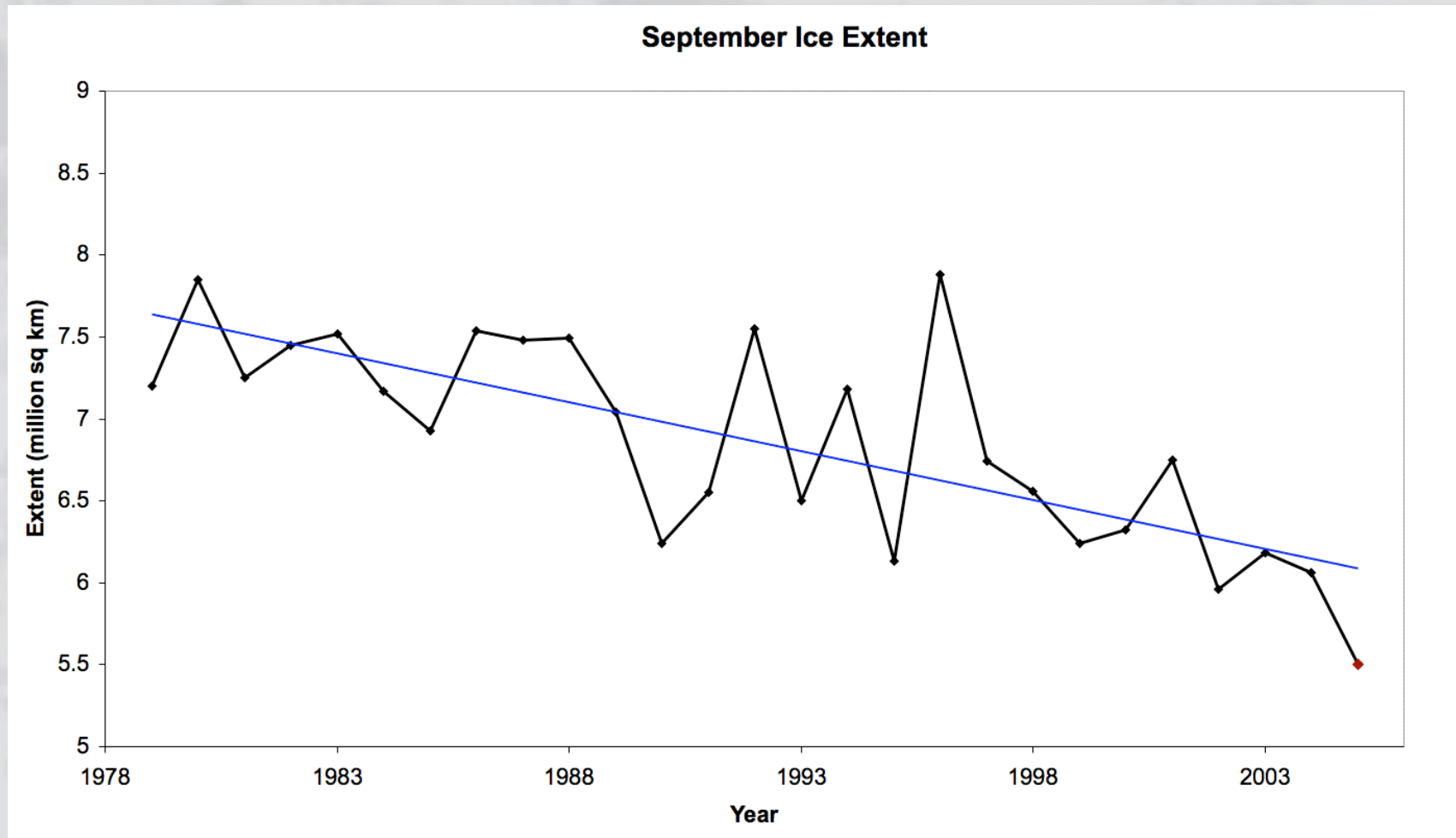
Ulrike Niemeier and J.H. Jungclaus

Max Planck Institute for Meteorology, Hamburg, Germany

**L. Emmons, J.F. Lamarque, P. Hess, S. Walters,
X.X. Tie, P. Rasch and G.P. Brasseur**

National Center for Atmospheric Research, Boulder, Colorado, USA

Change in the extent of Arctic Sea ice from 1978 to 2005



From NSIDC/NASA news, 2005

Models used in the study:

1. Coupled General circulation model – Ocean model from the Max Planck Institute for Meteorology in Hamburg:

- General circulation model:

 - ECHAM-5 model (Roeckner et al., MPI report #349, 2003)
Horizontal resolution T63 (1.9 degrees lat/long)

- Ocean Model:

 - MPI-OM model (Marsland et al., Ocean Model., 5, 2003)
Horizontal resolution: 15 km (arctic) to 185 km (tropics)

- Coupling:

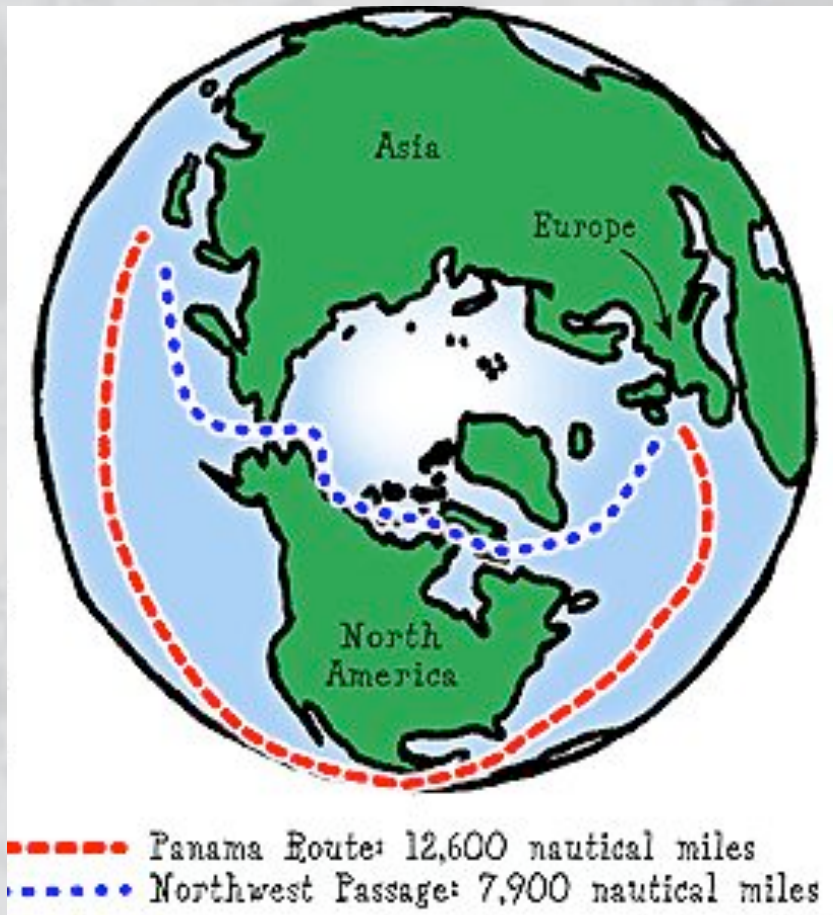
 - ECHAM-5 and MPI-OM are coupled with the OASIS coupler
Coupling time step : 1 day

2. MOZART-4 Chemistry-transport Model from NCAR, MPI and NOAA/GFDL (publication in preparation: Emmons et al., 2007)

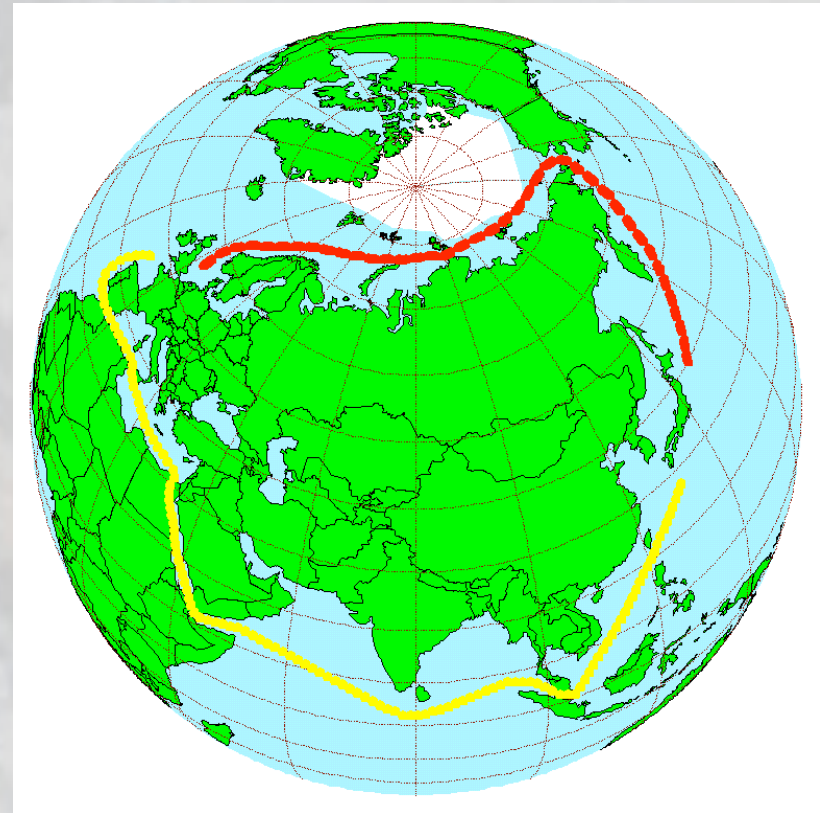
- Used to calculate distribution of gases/aerosols

 - Horizontal resolution T42 (2.8 degrees lat/long)

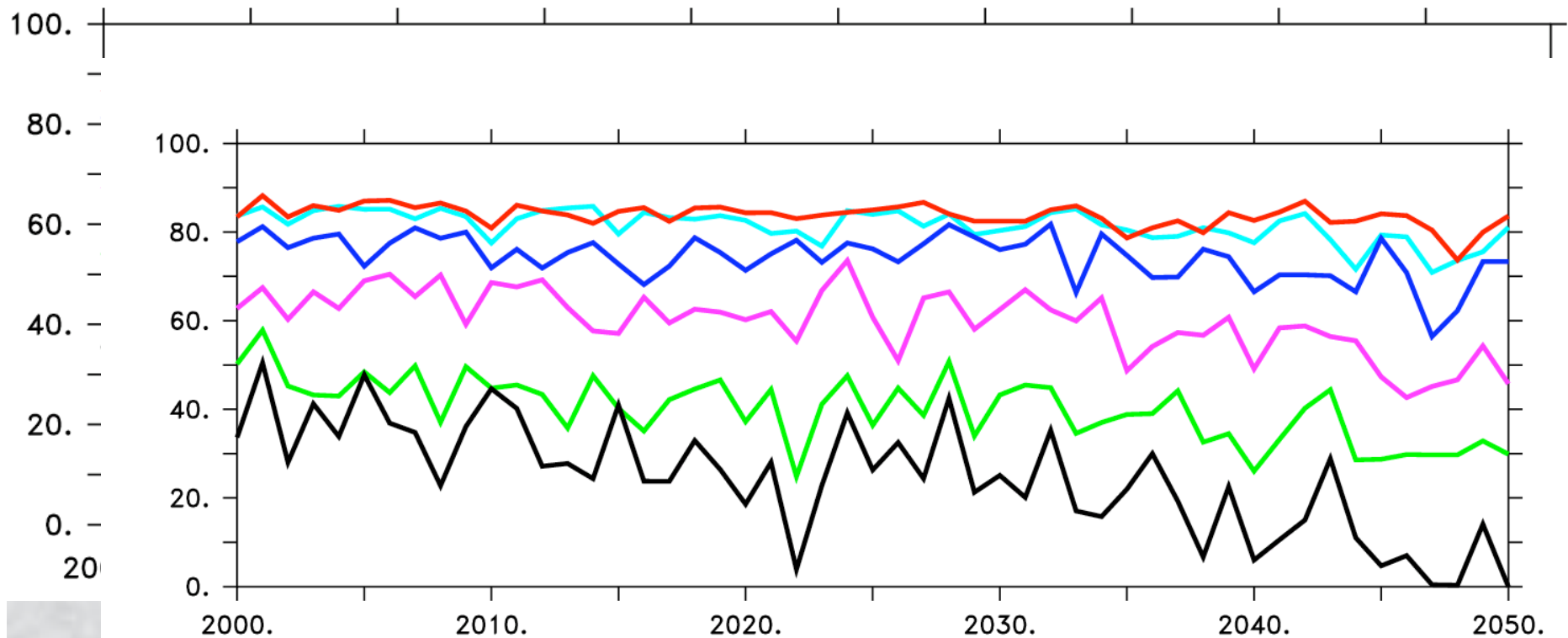
The Arctic Passages



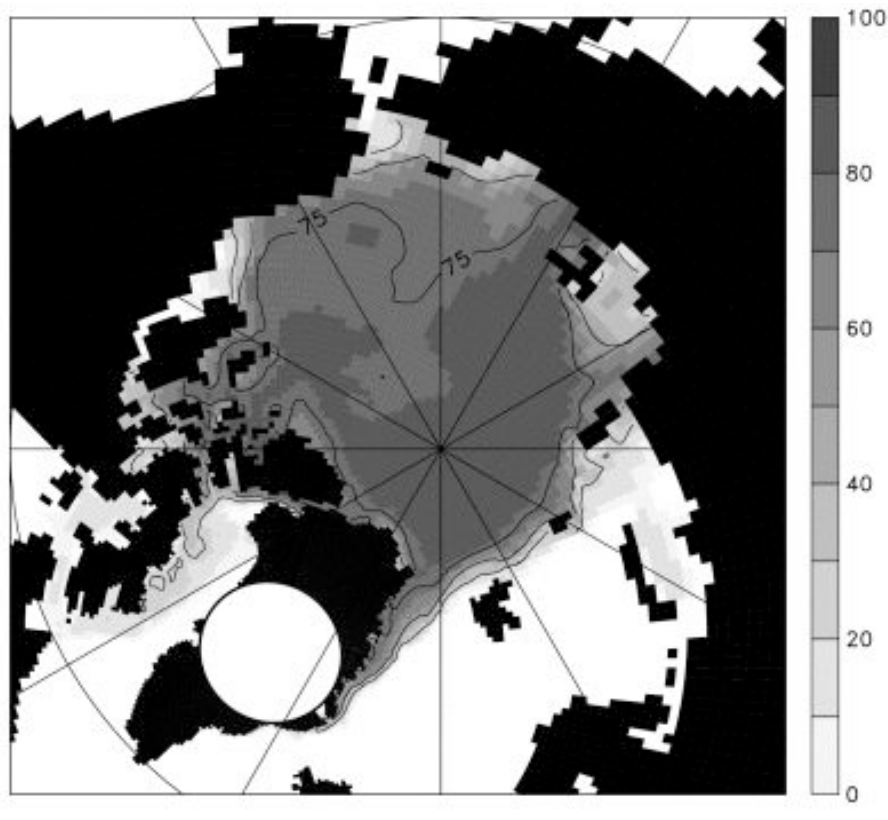
The Northwest Passage



The Northern Sea route

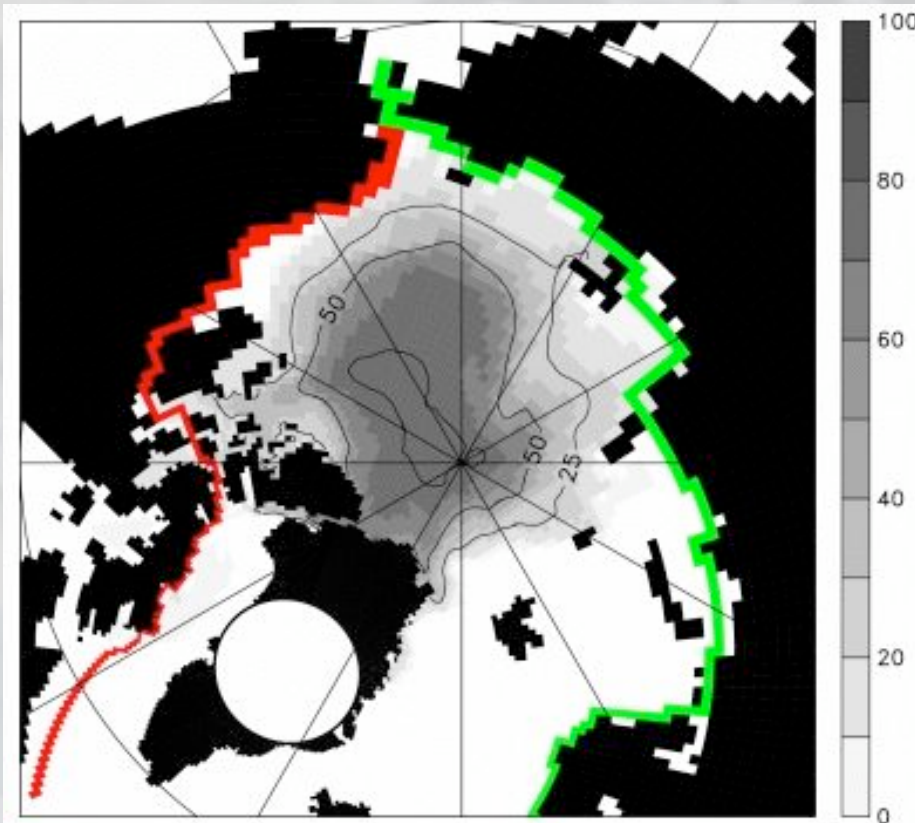


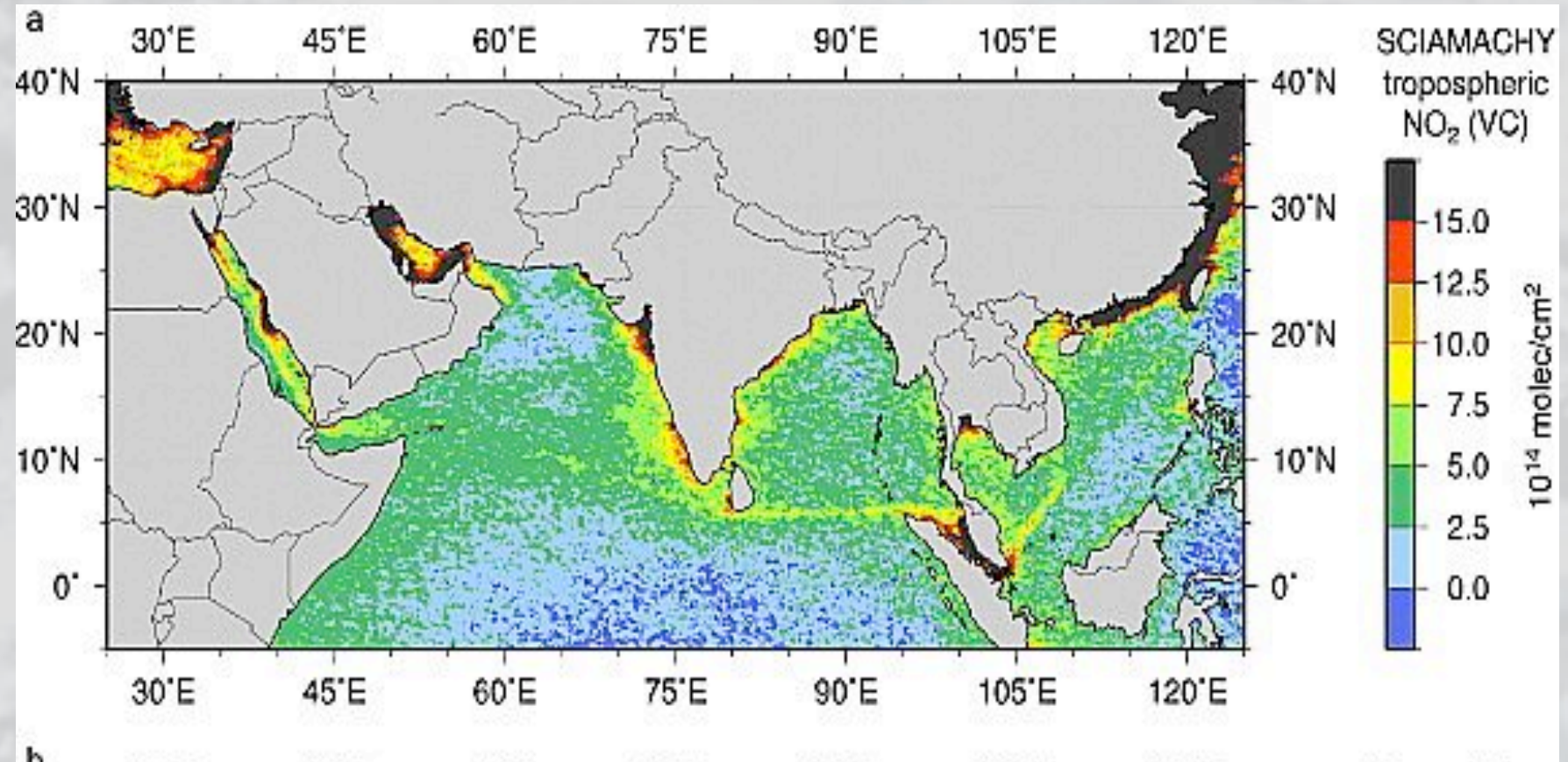
**Percentage of free ice in the North-East Passage
calculated by the coupled ECHAM5 – MPI-OM model**



**Ice cover in 2000 calculated
by the ECHAM5 – MPI-OM model**

**Ice cover in 2050 calculated
by the ECHAM5 – MPI-OM model**



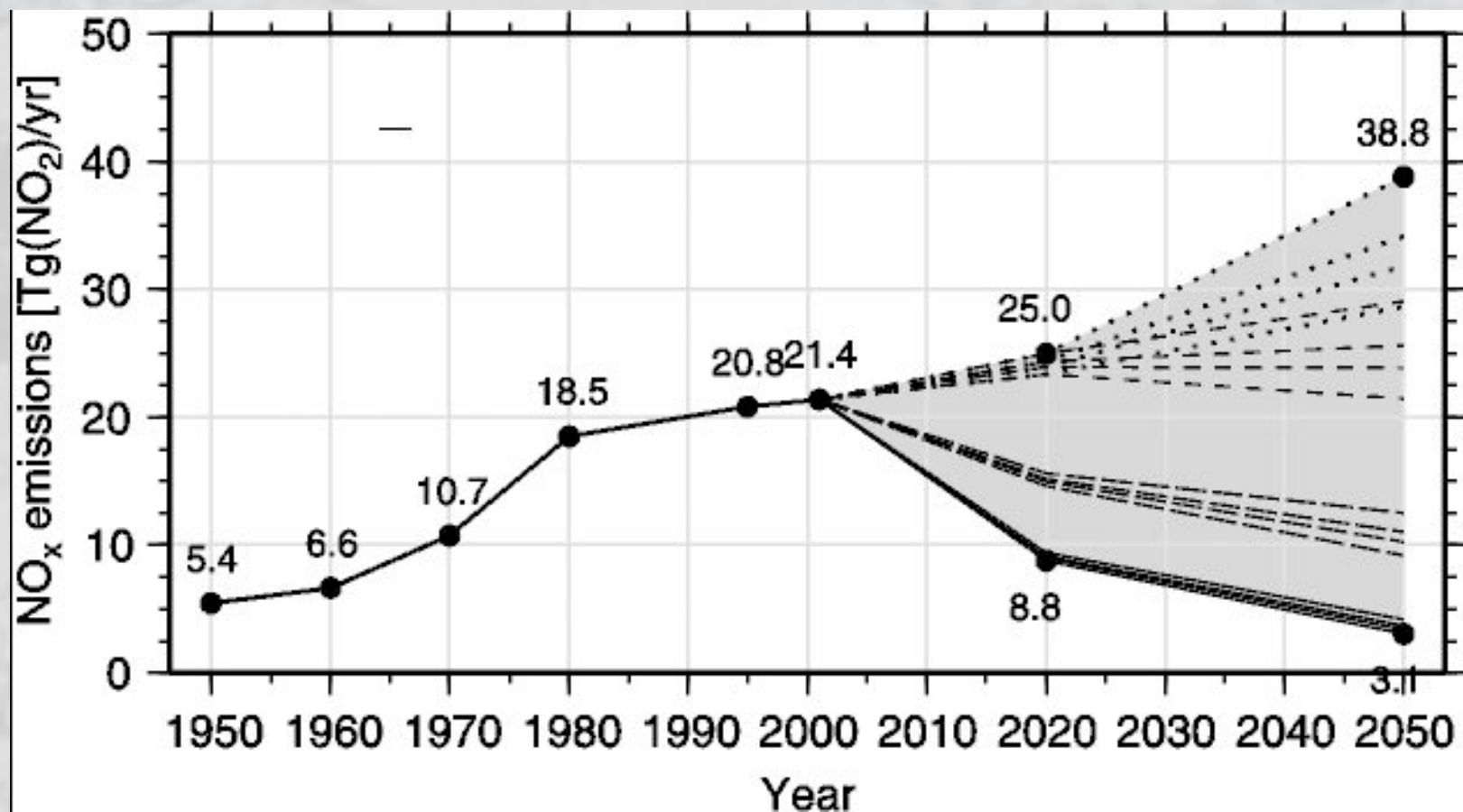


Observations of NO₂ from ships by SCIAMACHY
Richter et al., GRL, 2004

Uncertainties in global ship emissions

	Unit (../yr)	Endresen et al., JGR, 2003	Corbett and Koehler, JGR, 2003	Eyring et al., JGR, 2005
NO_x	Tg N	3.6	6.9	6.5
CO₂	Tg CO ₂	557.3	912.4	812.6
CO	Tg CO	1.1		1.3
SO₂	Tg SO ₂	6.8	13.0	12.0

NO_x ships emissions: 13-25% of total anthropogenic emissions - 9-18% of total emissions
SO₂ ships emissions: 5-9% of total anthropogenic emissions - 4-8% of total emissions



Eyring et al. , JGR, 2005: Possible scenarios for future emissions from shipping

Our ships emissions scenarios introduced in the MOZART-4 chemistry-transport model : based on Eyring et al., JGR, 2005

Eyring et al.

- (global increase of ships emissions from 2000 to 2050**
- (Use of DS4 Eyring et al.'s scenario =**
global increase of 5.3 Tg N/yr from 2000 to 2050

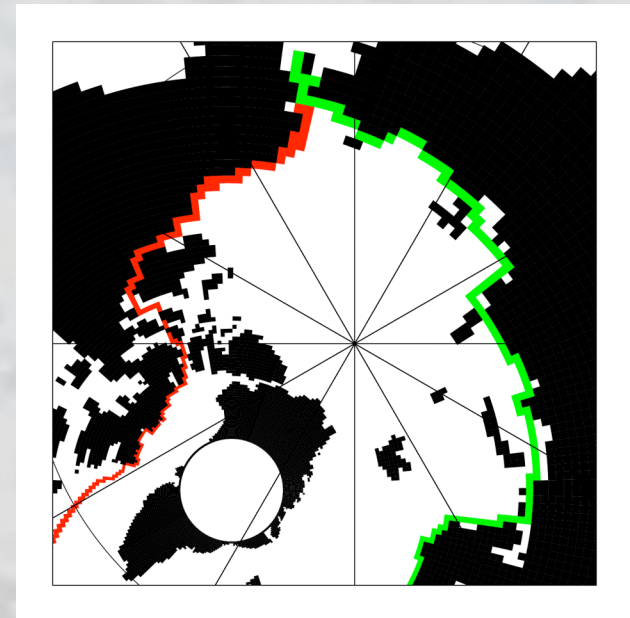
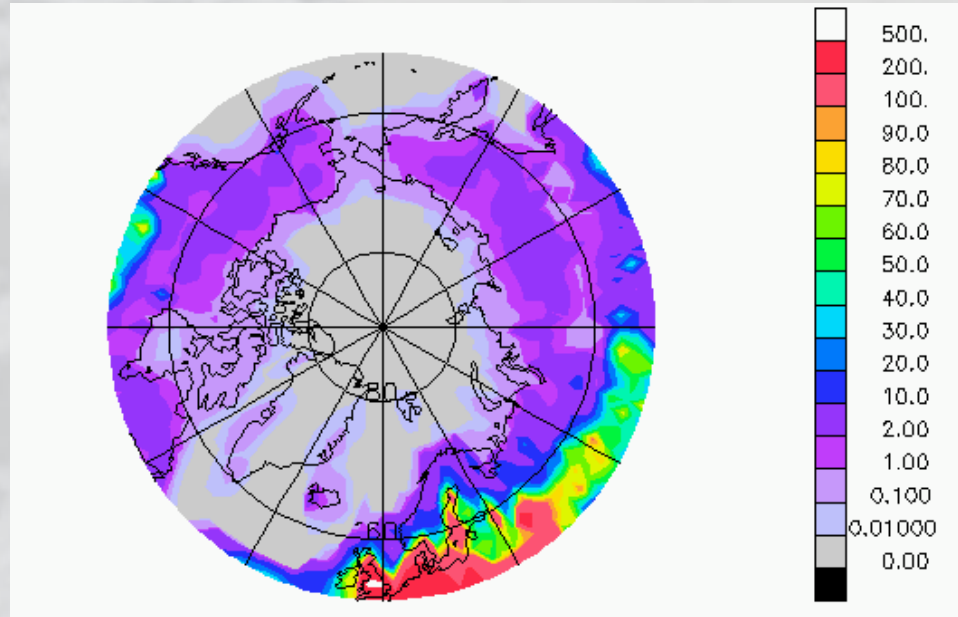
Our scenario assume that:

25% of this increase is due to ships cruising in the Arctic

We inject along the passages in 2050:

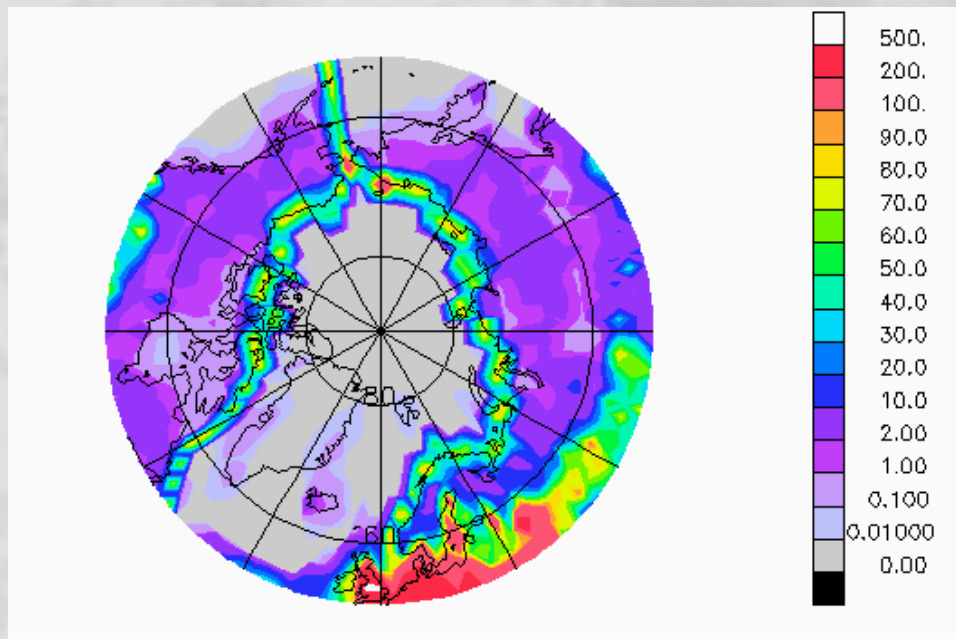
ships	2000 emissions (POET inventory)	
	anthrop.	total
1.4 Tg N/yr	27.5	37.8
0.32 Tg CO/yr	279	1299
1.83 Tg SO₂/yr	142	158
0.013 Tg BC/yr	3.1	11.5
0.026 Tg OC/yr	6.0	72.9

August 2000; no ships



ships emissions
equally distributed
along the 2 passages

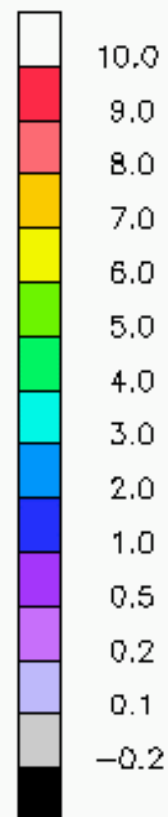
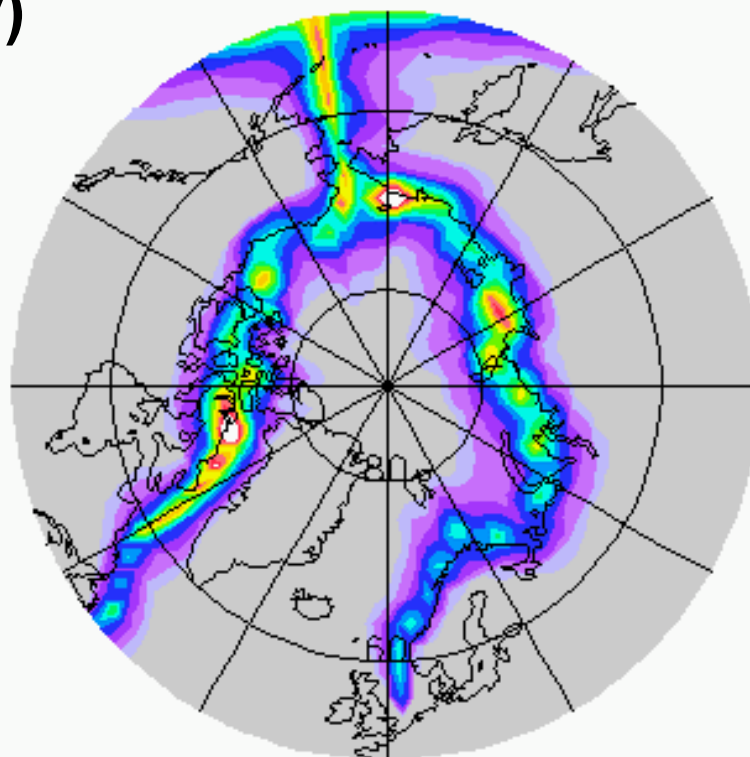
**NOx emissions
in MOZART**



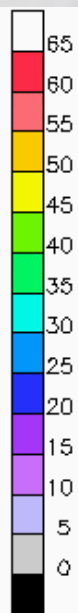
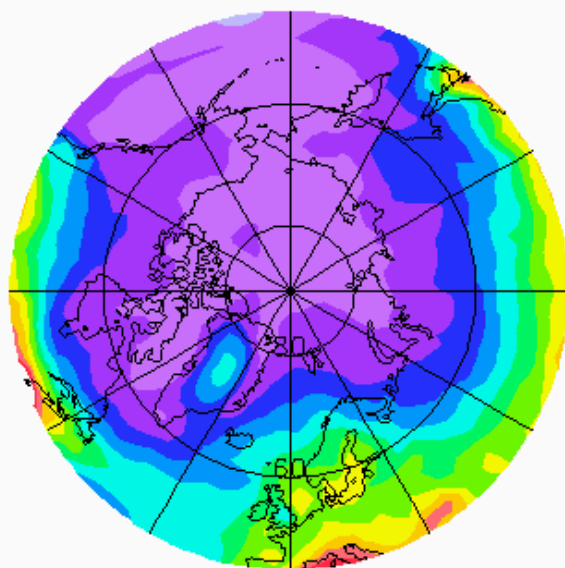
August 2050; with ships

July 2050 - July 2000

(ppbv)



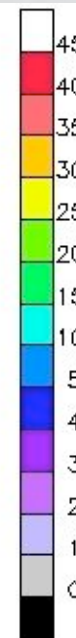
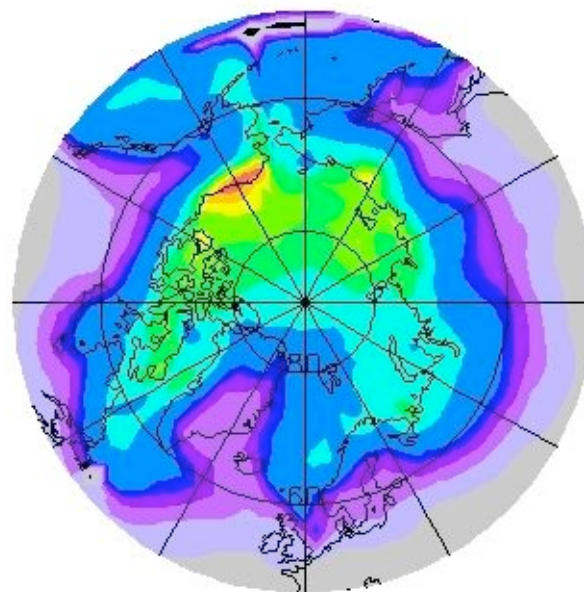
**Change in the NO_x distribution
in the Arctic resulting from ships
calculated by the MOZART model**



**Surface ozone
July 2000
ppbv**

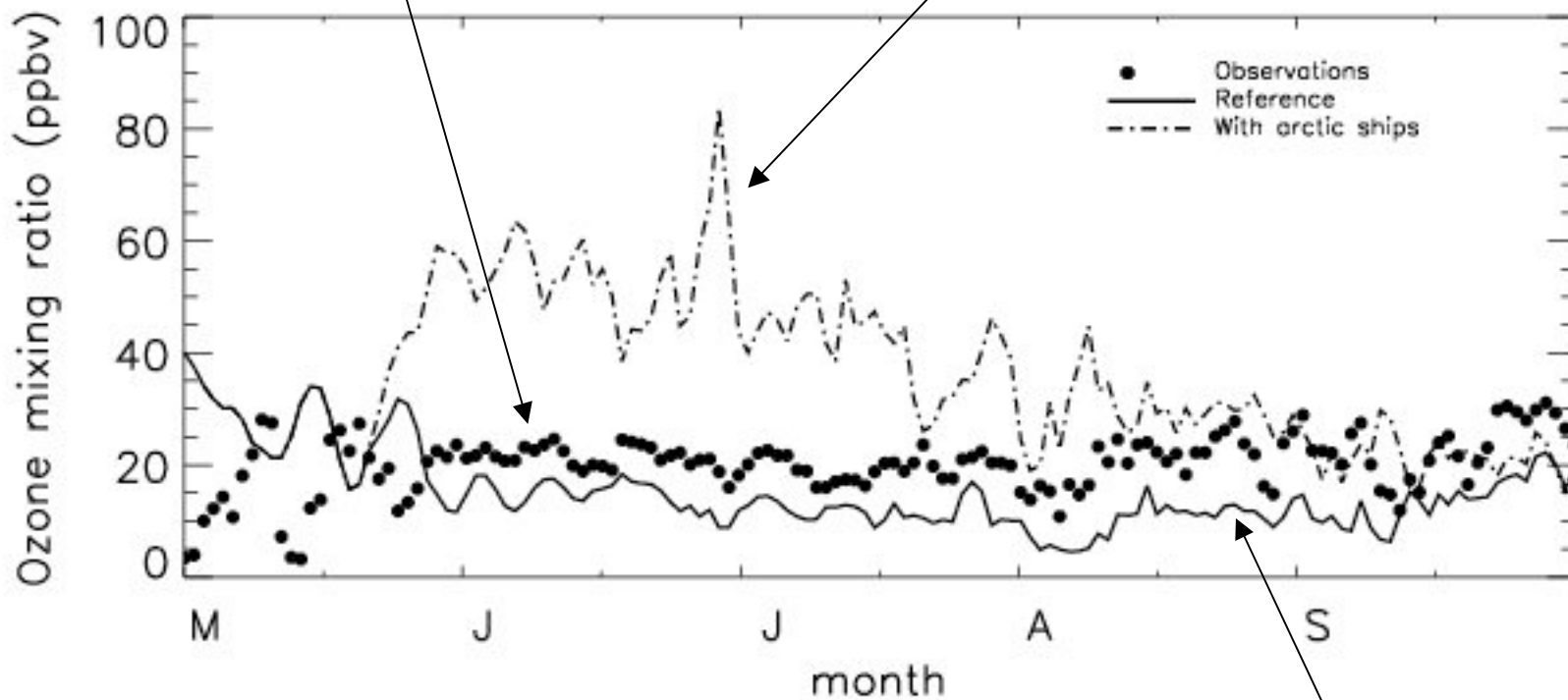
**Ozone calculated by
MOZART**

**Difference in surface ozone
July 2050 – July 2000
ppbv**



Observations

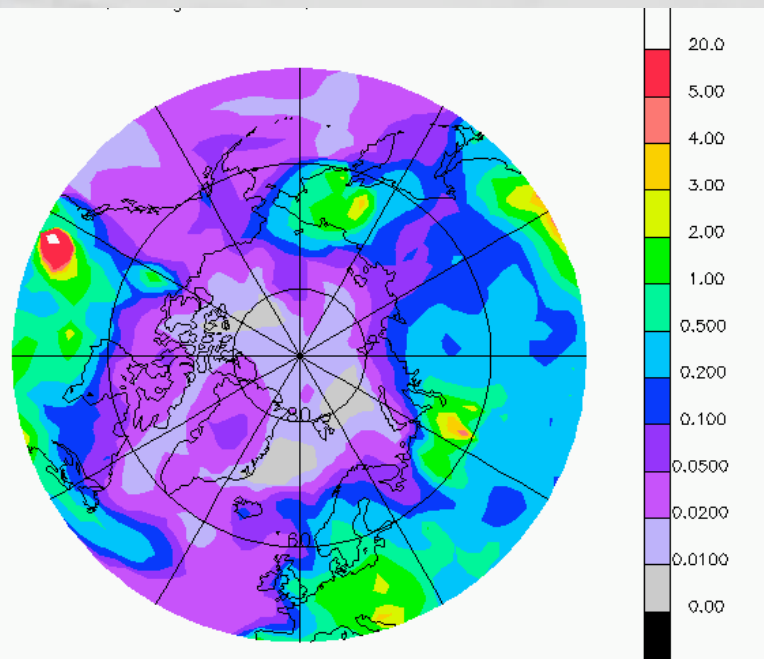
Model; with arctic ships



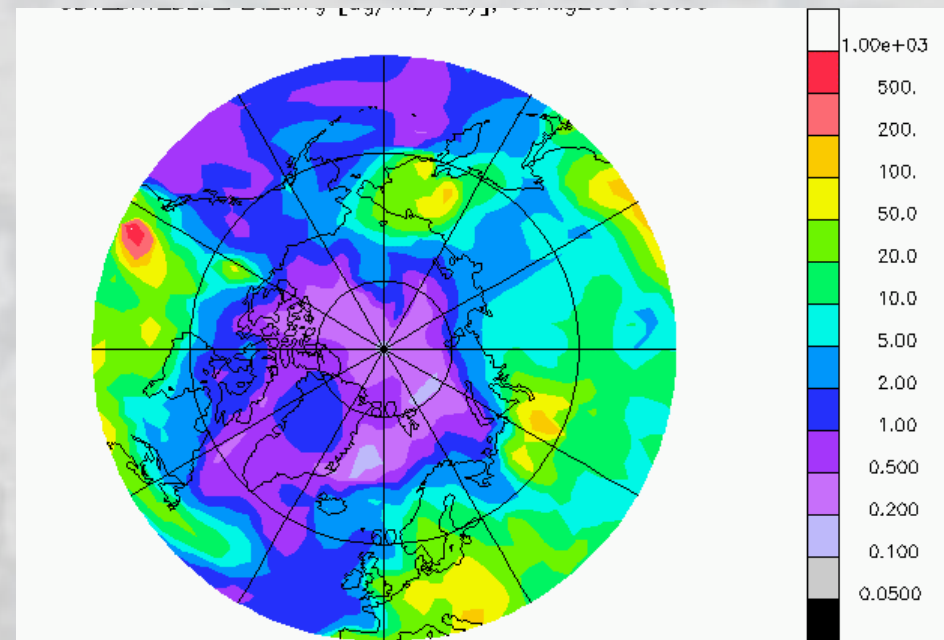
Model; reference

Surface ozone in Barrow, Alaska

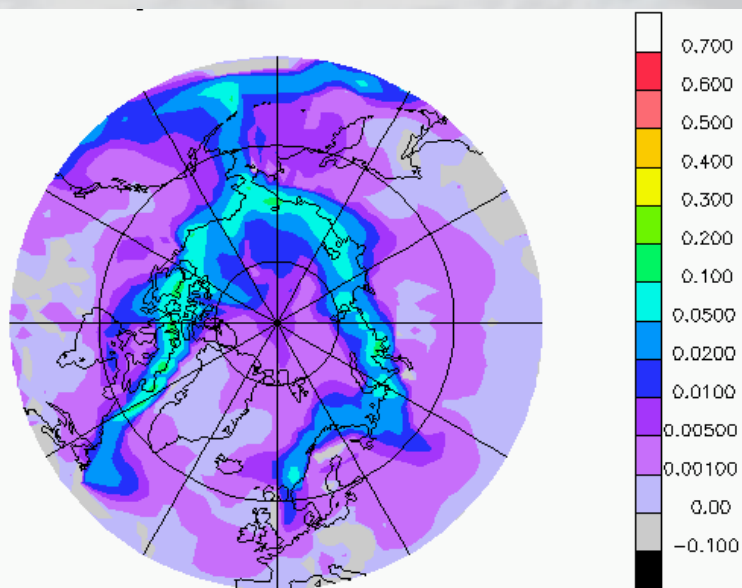
Black carbon (ppbv) - No ships - Aug, 5



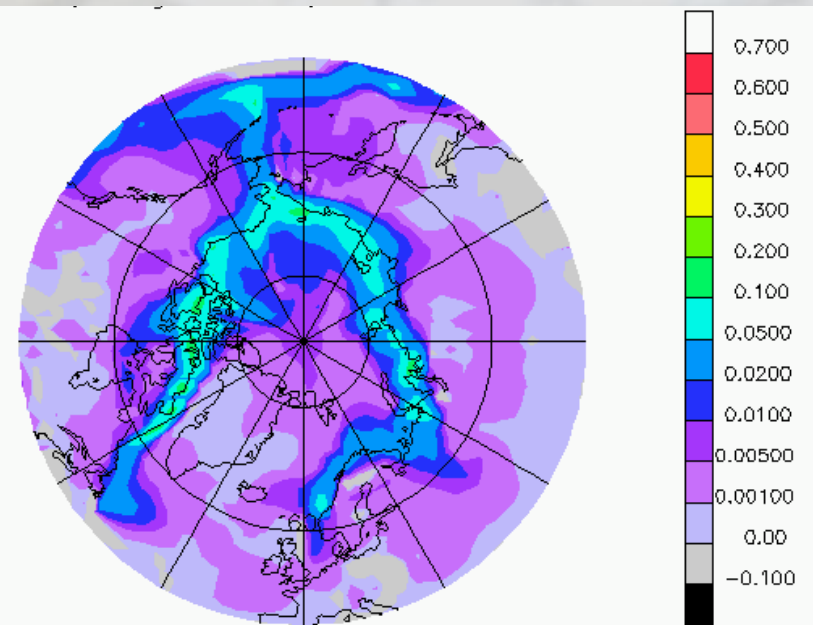
Black carbon deposition (ug/m2/day) No ships - Aug, 5



BC mixing ratio diff. [ships - no ships]



BC deposition diff. [ships - no ships]



On-going work

- | Look at ships impact at the global scale
[arctic + non-arctic ships]**
- | Evaluation of different scenarios [global/arctic]**
- | Change in albedo, climatic impact and ice melting rate**

Work on emissions

- | Evaluation of emissions, at the global and regional scales:
 - within GEIA (Global Emissions Inventory Activity, an AIMES/IGBP project)**
 - discussions in progress with HTAP****
- | Emissions web portal: www.geiacenter.org
Provides emissions inventories:
POET, RETRO, EDGAR, ABBI, MERCURY
more to come...**